Efficient Light Control System

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Problem and Objective

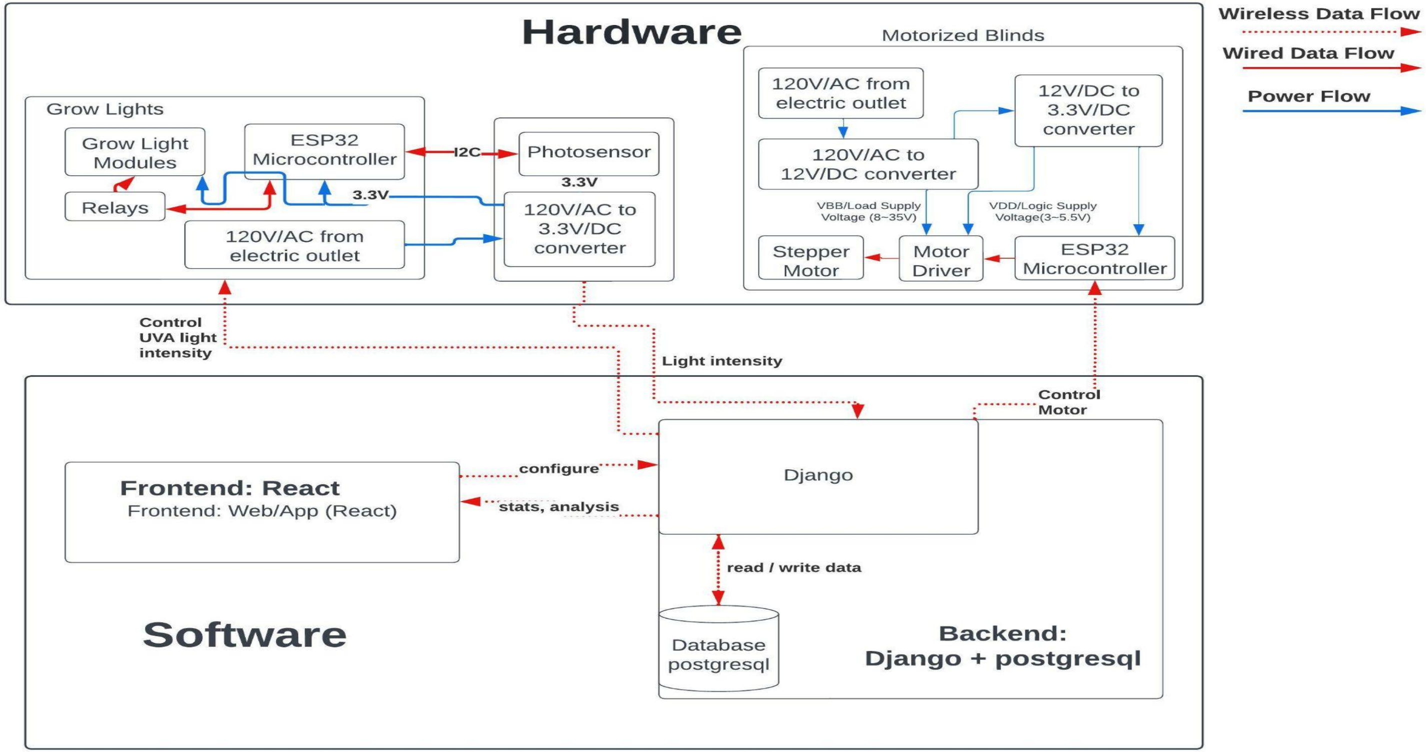
- Most LED grow lights are manual
- Inefficient and Inconvenient
- Combine sunlight and artificial light
- Achieve desired luminosity

Visual Representation

High Level Requirements

1. Wavelength of 400-700 nm, maximum of 3500 lux over 12 hours
2. Photosensor accurately measures illumination
3. Covers variety of plants

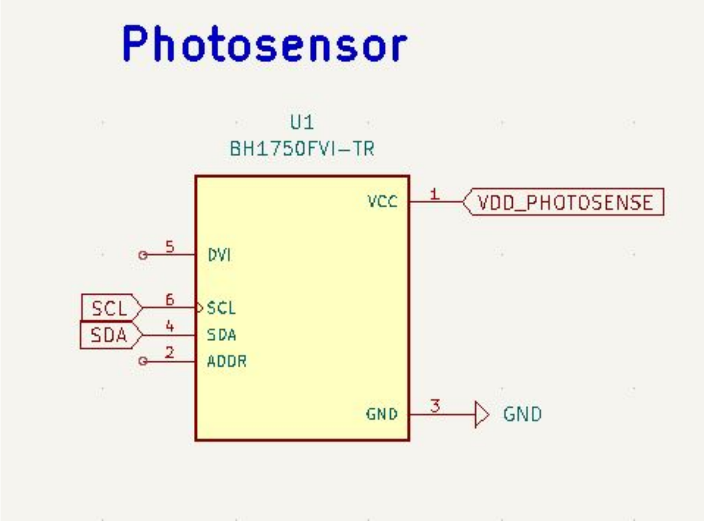
Original Block Diagram



Changes to the Design

1. ESP32 on the PCB
2. Transistors instead of Relays: cost effective and reliable

Subsystems: Photosensor



Wavelength Requirement in Plant Growth

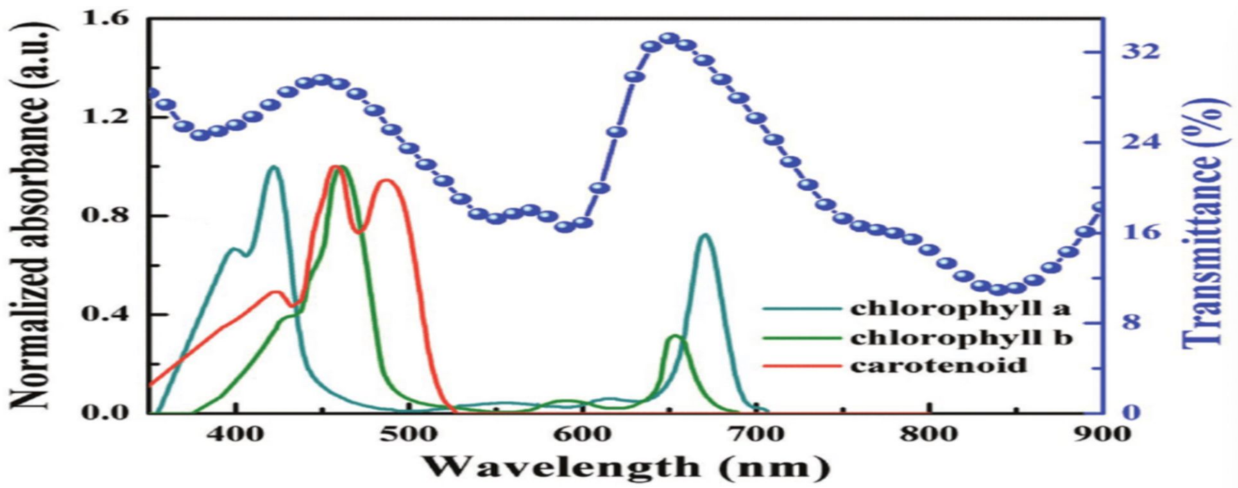
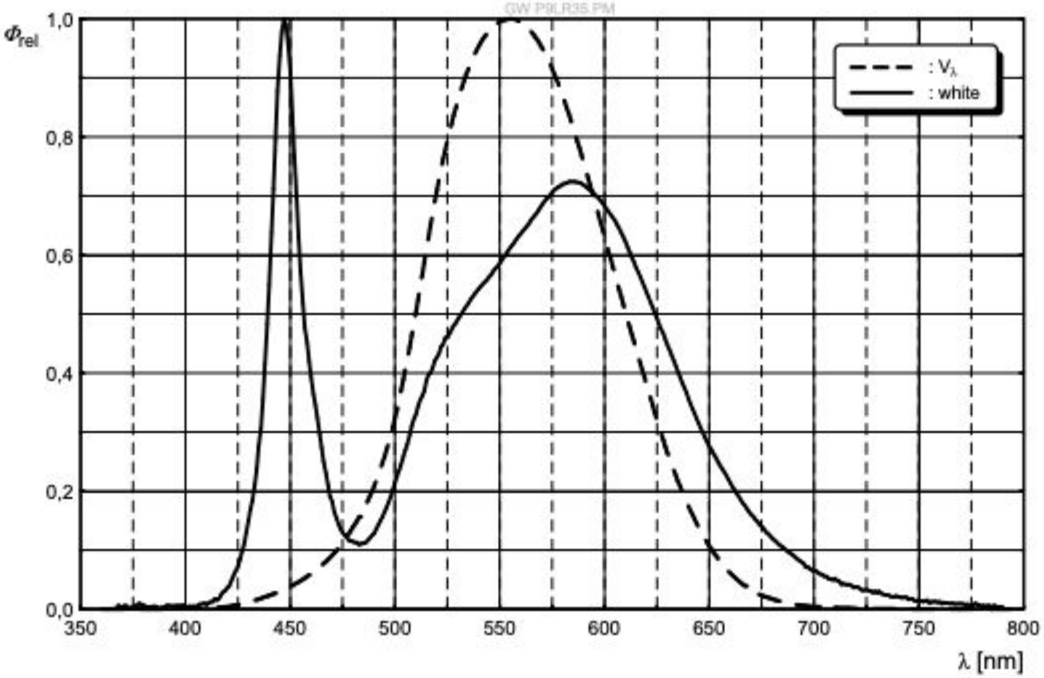
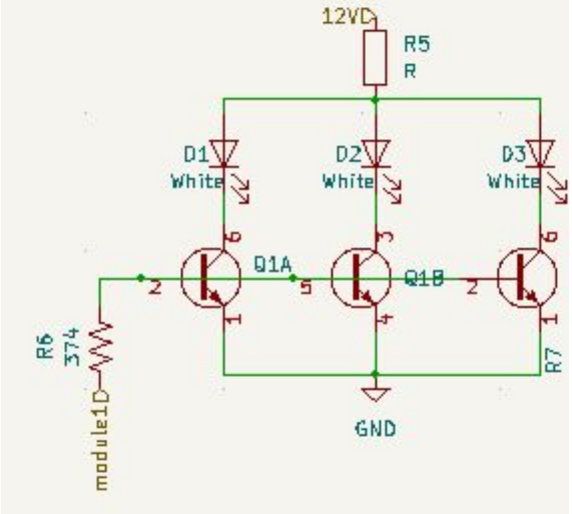


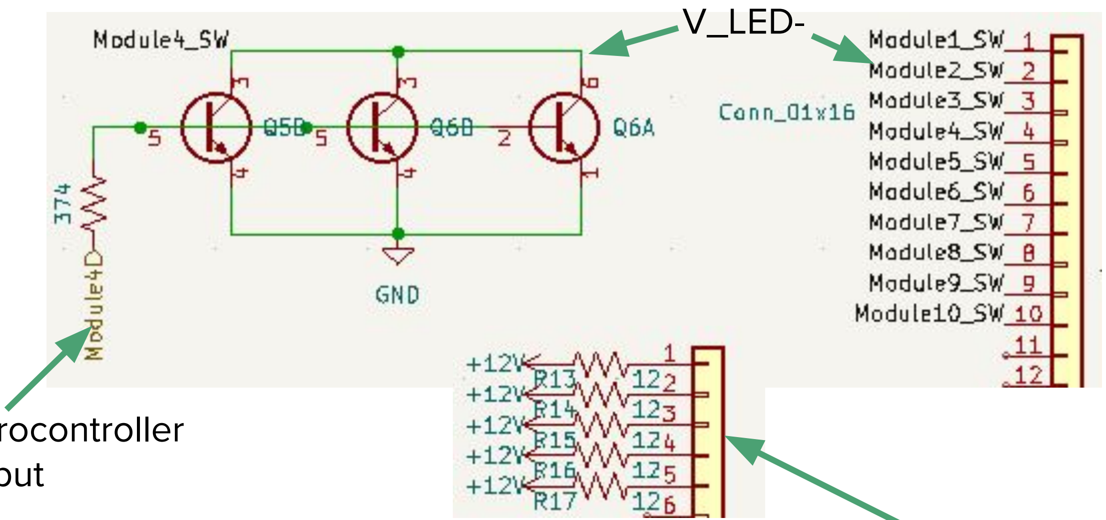
Figure 12: Wavelength vs Normalized Absorbance for Plants

LED Wavelength



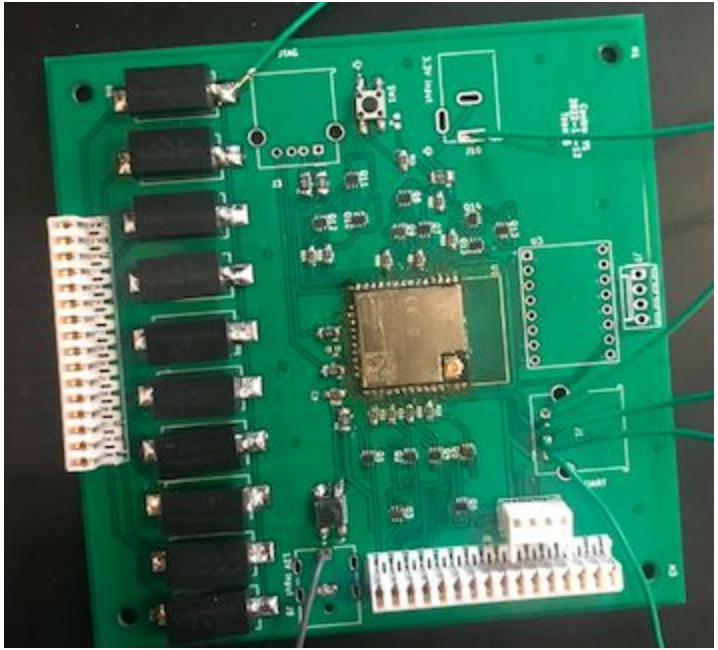
Subsystems: Grow Lights

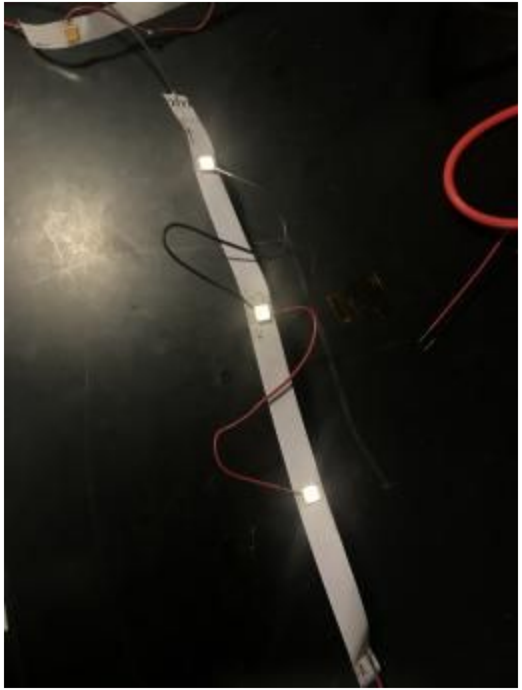




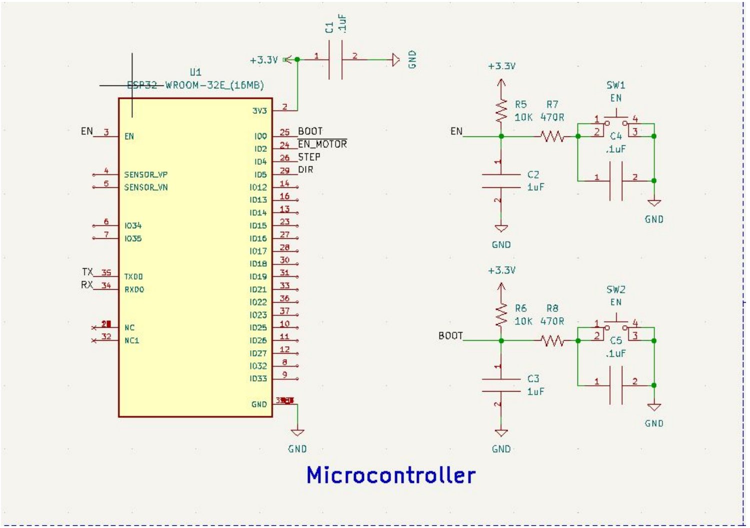
Microcontroller output

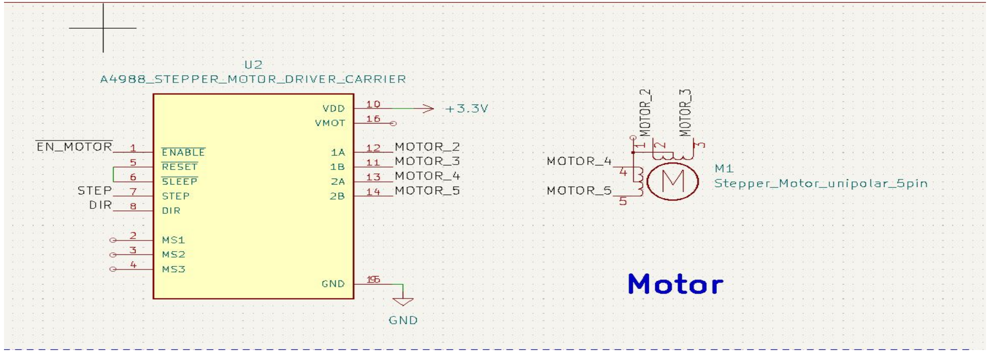
V_LED+





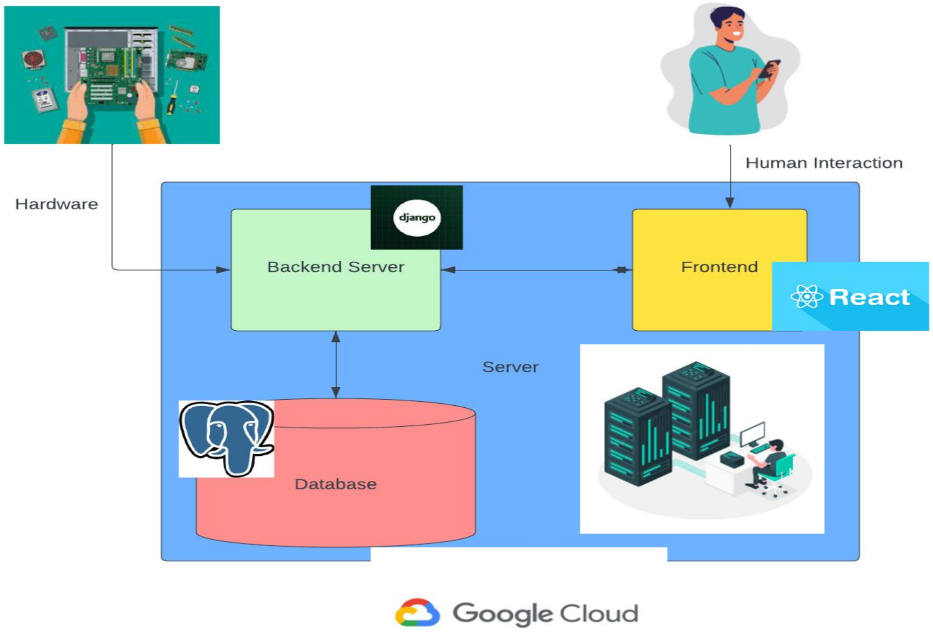
Subsystems: Motorized Blinds





Subsystems: Motorized Blinds

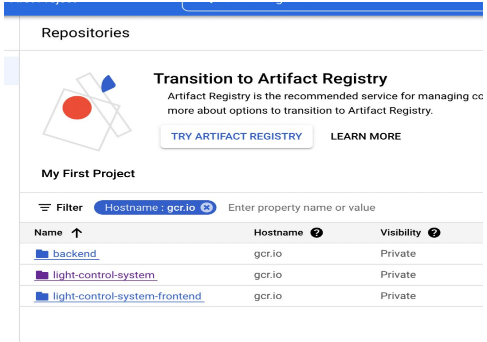
Software Structure

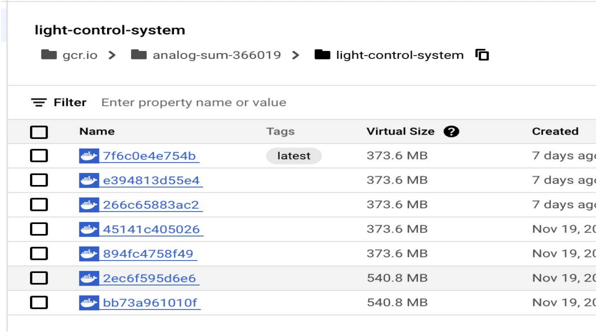


Docker

Containerize the application

- Cloud server runs this image
- Independent of development environment

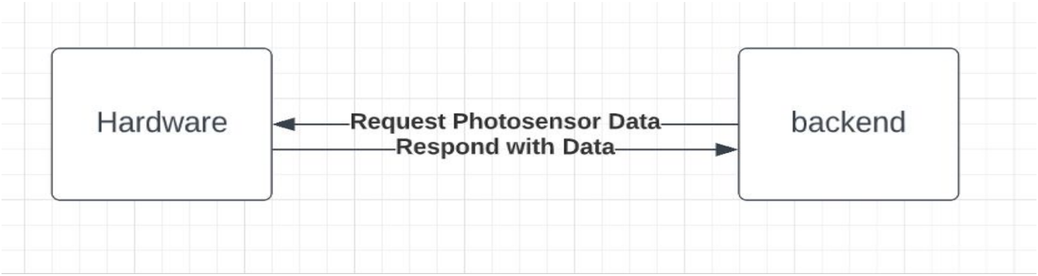




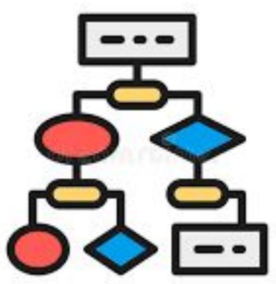
Data Acquisition

Accept light intensity data from the hardware

- Every other 0.1 seconds
- All data were received within 100 ms latency



Decision Maker



Analyze the current status and take an action

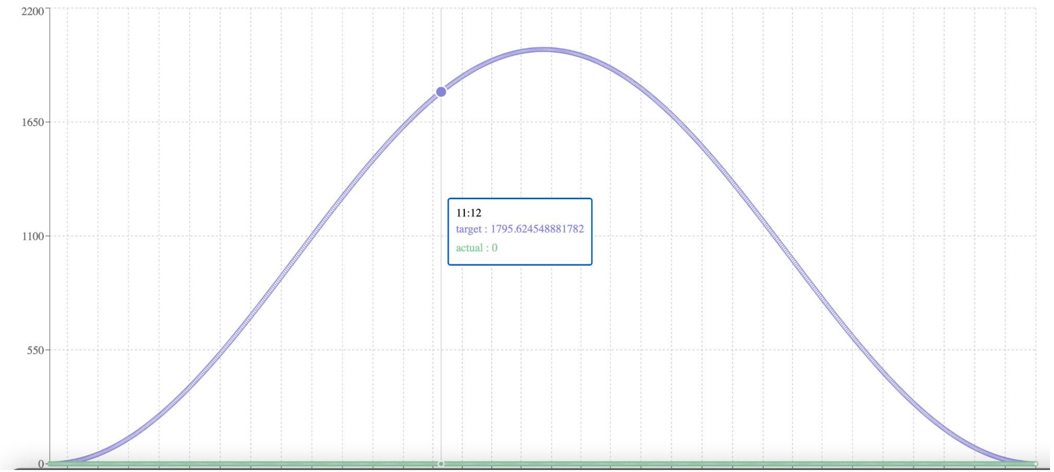
1. Calculates target illumination
2. Take an action
    - The system needs more light => open the blind / turn on LEDs
    - The system needs less light => close the blind / turn off LEDs

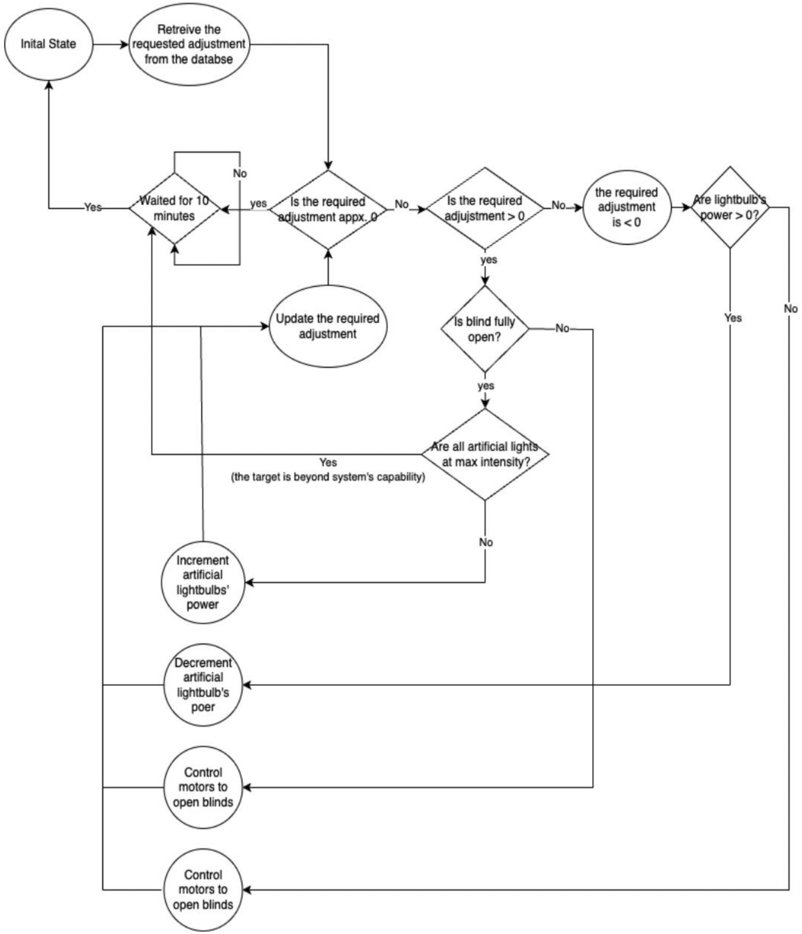
Target illumination calculation

You can measure the flux density at the tip of the atmosphere by

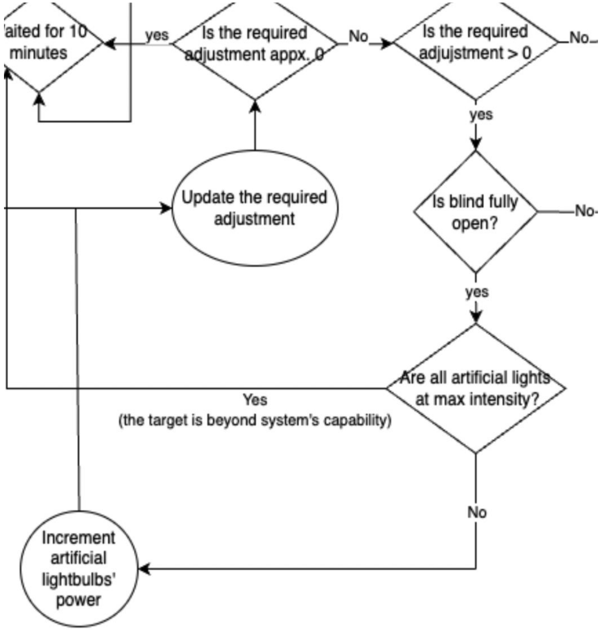
$$F = F_0 \times \cos \theta_0$$

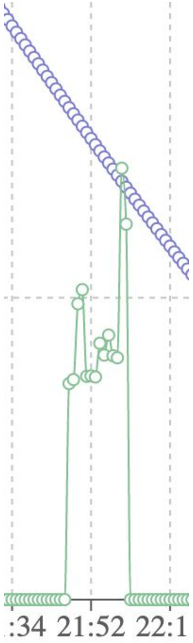
Target vs Actual




Inital State
Retreive the requested adjustment from the databse
Waited for 10 minutes
No
Yes
yes
Is the required adjustment appx. 0
No
Is the required adjujstment > 0
No
the required adjustment is < 0
Are lightbulb's power > 0?
yes
Update the required adjustment
Is blind fully open?
No
Yes
No
yes
Are all artificial lights at max intensity?
Yes
(the target is beyond system's capability)
No
Increment artificial lightbulbs' power
Decrement artificial lightbulb's poer
Control motors to open blinds
Control motors to open blinds

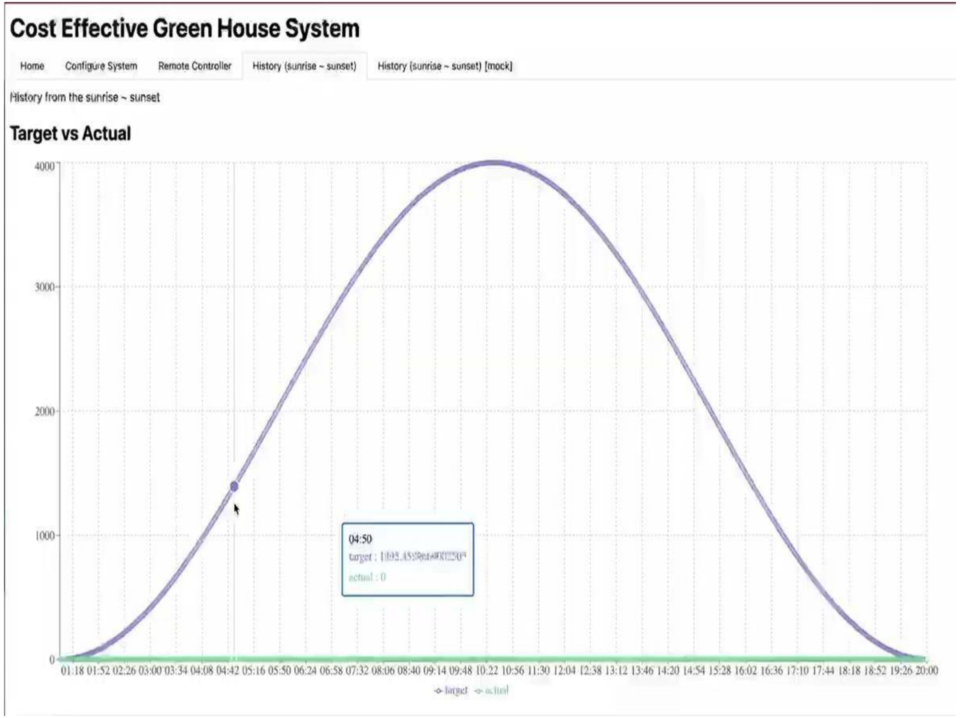
Logic flow when turning lights on



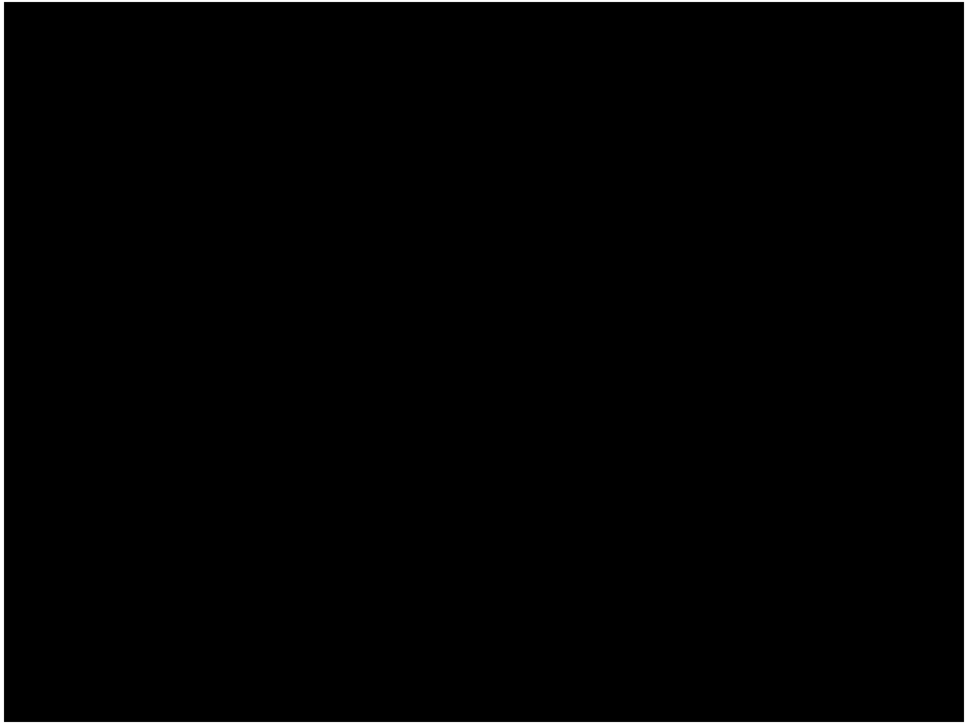


Quick Demo

http://localhost:3000/



Video of Project



Success and Challenges

- Each individual subsystems function
- Integration between software and grow light module
- ESP32 without an antenna had low quality connection
- Failed to have the chip connected to wifi by itself

Conclusion

- Always double check power ratings, ESP32 damaged due to excess current drawn
- Higher quality connectors, better wire management
- Potentiometer to have more adjustability of luminosity

Recommendations for Further Work

- Manufacture a board specifically for LED arrangement
- Clean up wires, reconsider and change the photosensor subsystem
- Add a hanging system to the panel
- Connect ESP32 directly to wifi